Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
FEB 2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Molten Metal Explosions are Still Occurring	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **The Aluminum Association, Inc,1525 Wilson Boulevard,Arlington,VA,22209**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

See also ADM002300. Presented at the Minerals, Metals and Materials Annual Meeting and Exhibition (138th)(TMS 2009) Held in San Francisco, California on February 15-19, 2009. Sponsored in part by the Navy. U.S. Government or Federal Purpose Rights.

14. ABSTRACT

There have been extensive efforts to prevent molten metal explosions in aluminum plants; however, explosions continue to occur. The Aluminum Association continues to collect reports on explosions occurring in the aluminum industry world-wide. Since the program was instituted by the Association in 1985 more than 2600 reports have been received and analyzed. The database is shared with the program participants to enhance awareness, to provide information for employee safety training and to provide guidance for the industry?s programs and prevention efforts.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**2**	

Light Metals 2009 *Edited by: Geoff Bearne*
TMS (The Minerals, Metals & Materials Society), 2009

MOLTEN METAL EXPLOSIONS ARE STILL OCCURRING

Seymour G. Epstein
The Aluminum Association, Inc.
1525 Wilson Boulevard
Arlington, Virginia 22209

Keywords: Aluminum, Molten Metal, Explosions

Abstract

There have been extensive efforts to prevent molten metal explosions in aluminum plants; however, explosions continue to occur. The Aluminum Association continues to collect reports on explosions occurring in the aluminum industry world-wide. Since the program was instituted by the Association in 1985 more than 2600 reports have been received and analyzed. The database is shared with the program participants to enhance awareness, to provide information for employee safety training and to provide guidance for the industry's programs and prevention efforts.

Introduction

Millions of pounds of molten metal are produced, remelted, transferred and cast by a variety of methods in the aluminum industry every day, safely and without incident. However, as with other molten substances, molten aluminum can explode when contacted by water or other contaminants.

For the past 60 years, the aluminum industry has been studying such explosions and the conditions under which they occur. Numerous studies have been conducted at company laboratories, at national laboratories, and at independent research centers in an effort to gain an understanding of these phenomena and how they may be prevented.[1] Many of these studies were sponsored by The Aluminum Association as part of its ongoing program on molten metal safety. [2]

A key element of the Association's safety program is a world-wide reporting of molten metal explosions. The program was created to glean as much information as possible from events occurring in the plants and the conditions under which they occur.[3] The program has been in place since 1985 and serves to enhance awareness, to provide information for employee safety training and to provide guidance for the industry's programs and efforts to prevent these occurrences.

The incident reporting program currently has 180 participants reporting for about 300 plants located in more than 20 countries. As of the date this paper was written, the Association had received nearly 2600 reports of incidents occurring world-wide. More than 100 reports were received for calendar year 2007.

Discussion

Based on the many years of research and the many investigations of plant explosions, it was concluded that three distinctly different types of explosions can occur when molten aluminum contacts and reacts with water or other contaminants. These were defined as Force 1, Force 2, and Force 3 explosions and are characterized as follows:

Force 1 Explosions, also referred to as "steam explosions" and commonly called "pops," occur when molten metal traps water which quickly turns to steam and expands more than 1,000 times. These explosions are characterized by metal dispersed a short distance, up to about 15 feet (4.5 meters) and often less than 10 pounds (4.5kg) of metal, with little or no property damage.

Force 2 Explosions are violent steam explosions. As with Force 1 explosions, water is trapped and turns to steam. But in this case, possibly due to confinement, the steam pressure is not as easily relieved and builds up to the point that considerably more metal is thrown a greater distance. The Force 2 explosion is characterized by metal dispersed 15 to 50 feet (4.5 to 15 meters), often to the roof of the plant, and there may be some accompanying property damage.

Force 3 Explosions are catastrophic events arising from reaction of molten metal with oxygen from water and/or air, with other oxidizing agents, or with contaminants such as fertilizer. They are characterized by considerable property damage and metal dispersed more than 50 feet (15 meters) away; often the metal has disappeared and what remains is a white powder, aluminum oxide.

It is virtually impossible to predict the magnitude of an explosion that will occur even under supposedly comparable conditions. However, based on the incident reports received over the years some general observations can be made relative to the principal operations in which the explosions occurred.

Reduction: The vast majority of reported explosions in reduction cells were rated Force 1 (still referred to as "pops") resulting from a wet or cold tool or wood pole (to control an anode effect) inserted into the bath. In a few cases more violent explosions occurred when a wet anode or wet scrap were placed in the pot.

Melting: In recent years the one operation giving rise to the most reported incidents has been remelting. And within that operation, furnace charging has been identified with the majority of the violent Force 2 and Force 3 explosions. Charging wet scrap, sows that were not preheated, ingots and T-bars with condensation, alloying elements and salt flux with moisture, and aluminum fines have all been mentioned as probable causes.[4,5,6] Contamination in the charge, particularly fertilizers such as ammonium nitrate, presents an especially hazardous situation and has been responsible for a number of reported Force 3 explosions. Contamination was suspected in a violent explosion that occurred recently in a sweat furnace in a recycling plant. Another recent

catastrophic event occurred in China when molten metal flowed from the furnace and into a pit with water; the resulting explosion destroyed the plant.

Transfer: Incidents in this operation are predominantly Force 1 with metal popping from unheated troughs, crucibles, ladles, etc. Exceptions are steel drain pans which can give rise to Force 2 incidents if unheated or contain foreign matter. Handling hot dross represents a particular hazard. Force 3 explosions have occurred from hot dross transfer, cooling and dumping into storage areas. In one recent incident, an employee reportedly dumped a load of thermiting dross into a water puddle and was fatally burned.

Casting: Incidents continue to be reported for dc casting arising from bleed-outs, wet starting blocks and the ingot head brought below the mold, mostly at the start of the cast. These and other causes have been detailed in two recent papers.[7,8] Casting into pig and sow molds can result in Force 1 or Force 2 explosions if moisture is present in the molds. One unusual event occurred recently in a recycling plant casting small ingots over a water tank. An explosion occurred that extensively damaged the machine and surrounding area; the cause has not been determined

Awareness of the potential hazards associated with handling molten metal and employee training are vital in preventing explosions.[9] The Association publishes and distributes information, guidelines and audiovisual training aids to foster awareness.[10,11,12] Presentations and short courses on safe handling of molten aluminum have been arranged with professional societies, such as TMS, and trade organizations, and workshops are conducted at members' plants. Regional Casthouse Safety Workshops are held at regular intervals in the U.S and have been held in Europe as a joint activity with the European Aluminium Association (EAA) and the International Aluminium Institute (IAI).

These efforts on the safe handling of molten metal continue to be a major part of the Aluminum Association's program to help its members achieve their goal of safe, healthy workplaces for their employees.

Acknowledgements

The efforts of the many industry representatives who have served on the Association's molten metal task forces, the Editorial Board for the Third Edition of Guidelines for Handling Molten Aluminum and participated in the safety workshops to share their considerable experience and expertise are appreciated. The author also acknowledges the invaluable assistance of Chuck Johnson, the Association's Director of Environment, Health & Safety, in the programs described above.

References

1. S. G. Epstein, "Causes and Prevention of Molten Aluminum-Water Explosions," Light Metals 1991 (1991).

2. S.G. Epstein, "The Aluminum Industry's Efforts to Prevent Molten Metal Explosions," Light Metals 2003 (2003).

3. S. G. Epstein, "An Update on the Reported Causes of Molten Metal Explosions," Light Metals 2007 (2007).

4. S. G. Epstein, "Recycling Aluminum Safely," Scrap, 57 (2000).

5. M.D. Bertram, F.R. Hubbard and D.C. Pierce, " Scrap Inspection Requires Ingenuity and Management," Light Metals 2007 (2007).

6. J.L. Zeh, "Safe Charging of RSI (Remelt Secondary Ingot) and Other Ingot Shapes into Melting Furnaces." Light Metals 2005 (2005).

7. R.T. Richter and J.M. Ekenes, "Cause and Prevention of Explosions Involving DC Casting of Aluminum Sheet Ingot," Light Metals 2005 (2005).

8. J.M. Ekenes and R.T. Richter, "Cause and Prevention of Explosions Involving DC Casting of Aluminum Extrusion Ingot," Light Metals 2007 (2007).

9. J.M. Ekenes, "Training for Preventing Molten Metal Explosions in Aluminum Cast Houses." Light Metals 2007 (2007).

10. "Guidelines for Handling Molten Aluminum, Third Edition," Aluminum Association Publication No. 69 (July 2002).

11. "Guidelines for Aluminum Scrap Receiving and Inspection Based on Safety and Health Considerations, Second Edition," Aluminum Association Publication GSR (2002).

12. "Guidelines for Aluminum Sow Casting and Charging," Aluminum Association Report GSC (1998).